# Visualization Using EnSight

Texas A&M University
Supercomputing Facility

# Acknowledgements


- This presentation has been designed from information collected from CEI's website, EnSight documentation, and training material and examples provided by EnSight staff.
- The initial version was revised based on many useful suggestions from the staff of the Texas A&M University Supercomputing Facility.

# Overview

- Introduction
- Overview of visualization capabilities
- Using EnSight in the TAMU environment
- EnSight data interfaces and formats
- Parts, frames, and cases
- The EnSight GUI
- Other Features
- Sample data files
- Demos

# Introduction

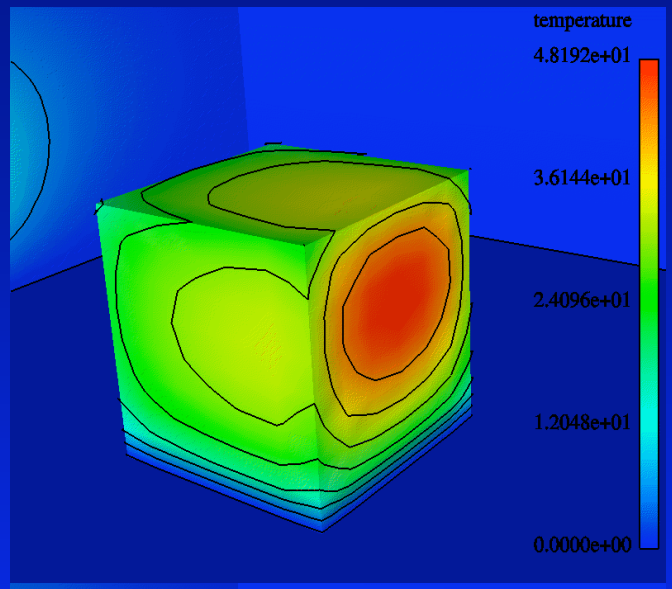
- Created by Computational Engineering International (CEI)
  - Originated as MPGS (Multi-Purpose Graphics System) from Cray
- It is an advanced software tool for the interactive visualization and animation of engineering and scientific data.
- Especially well suited to post-processing large finite element and CFD simulations
- Interfaces are provided to most commercial CAE software packages

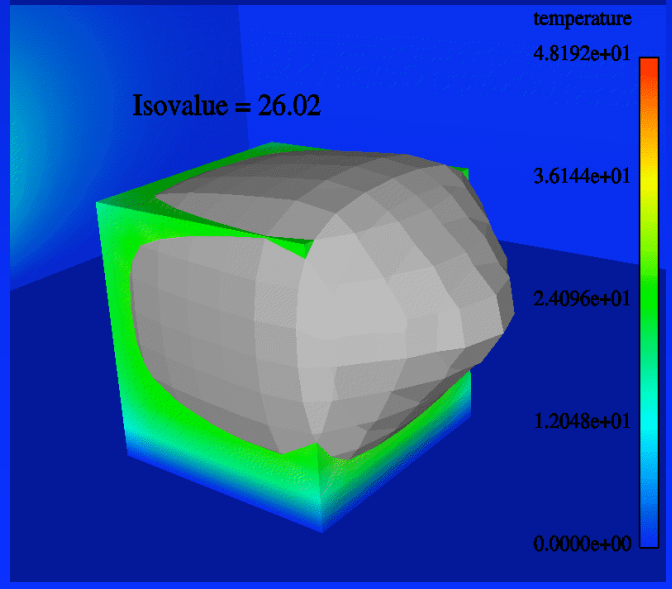
# What are some of EnSight's capabilities?

- Contours
- Isosurfaces
- Particle traces
- Clipping planes
- Vector arrows
- Elevated surfaces
- Displacement
- Profile plots
- Developed surfaces
- Tensor Glyphs
- Annotation
- Time and space animations
- Numerical queries

# Contours & Isosurfaces

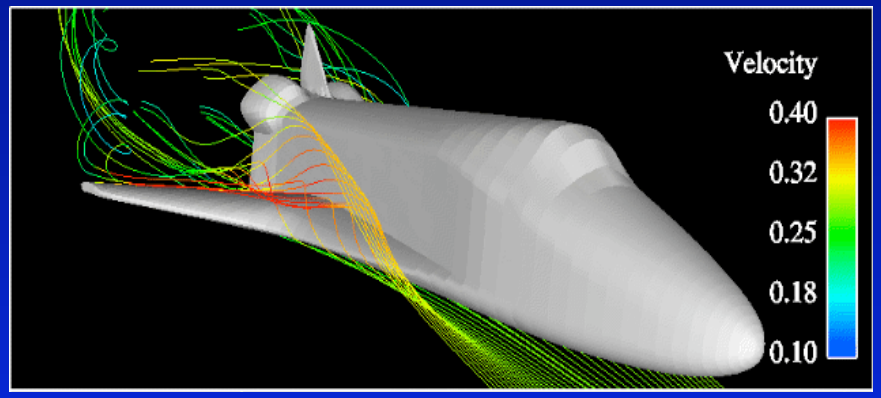
- displays contour loops of any active variable on any surface; individual loops can be labeled
- enables isosurfaces to be created based on scalar variable, vector component, vector magnitude or coordinate
- uses a slider to allow dynamic visualization of a range of isovalues

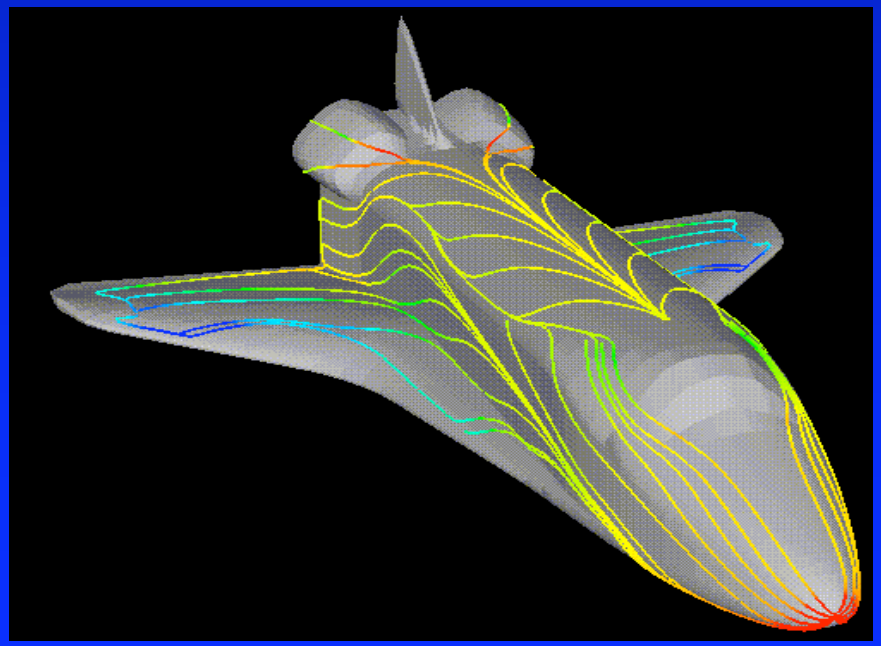


# Particle Tracing

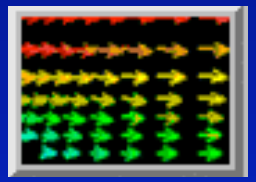
- allows streamlines, pathlines, streaklines and surface-restricted ("oil-streak") traces to be created
- displays traces as points, spheres, lines or ribbons
- allows trace emitters to be built from simple points, lines (rakes), planes (net) or the nodes of an arbitrary part

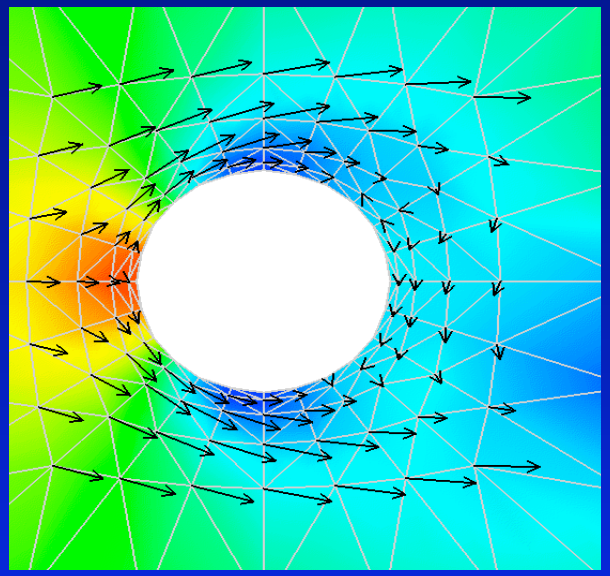


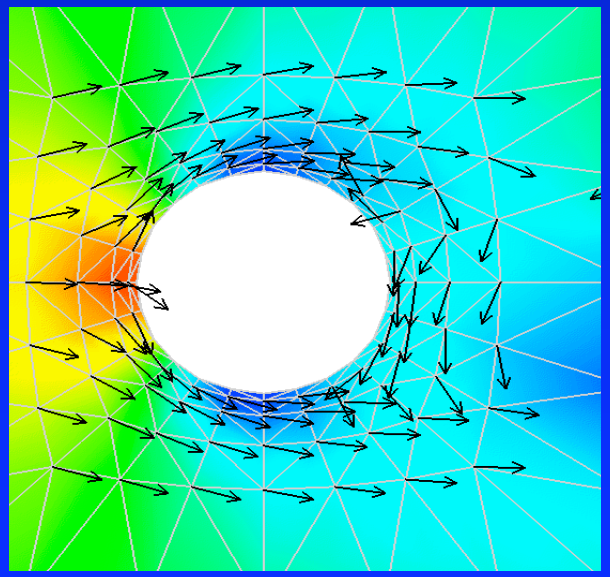



# Vector Arrows

- displays arrows showing direction and magnitude of a vector variable for any part
- allows control over color, scale, origin location, projection components, and arrowhead style
- provides curved arrows to show the local flow curvature

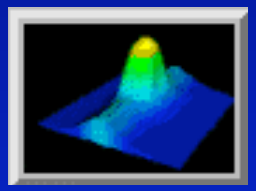


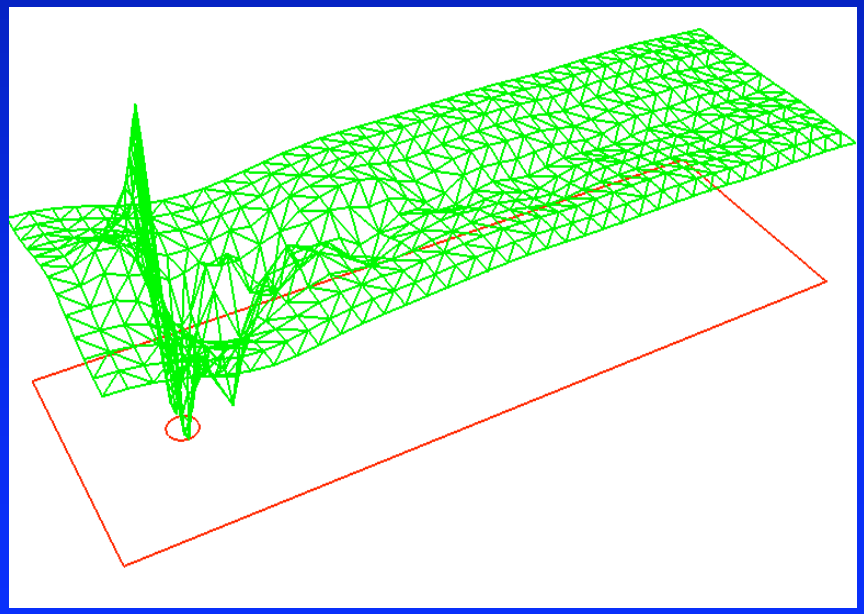




# Elevated Surfaces & Profile Plots

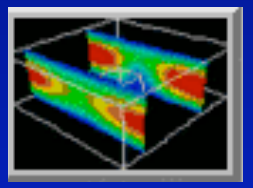
- enhances visualization by displaying elevated surface as a variable created by projecting away from a parent part
- provides profile plots as the 2D equivalent of an elevated surface
- profiles visualize values of a variable along a line with a variable heightplot

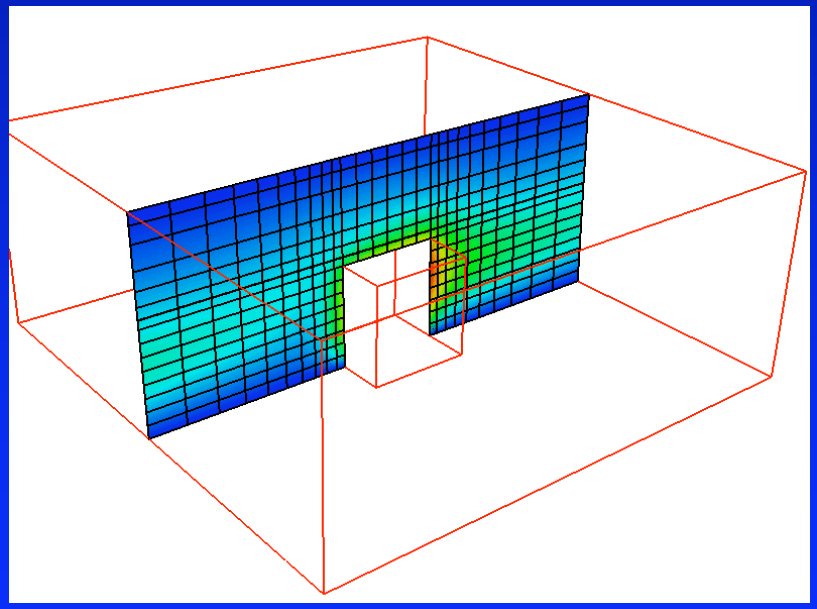




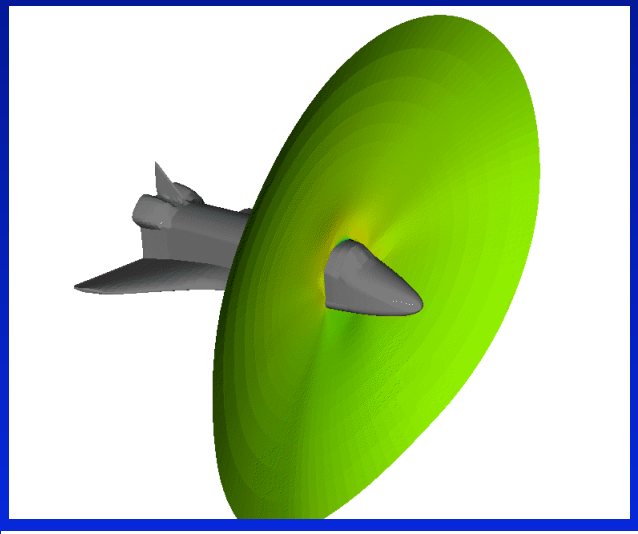
# Clips

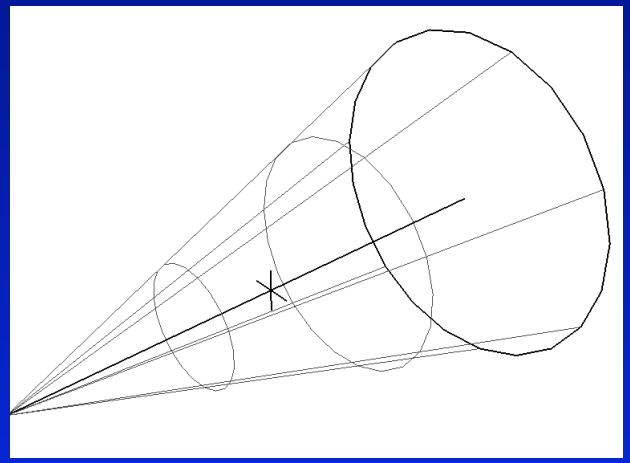
- A clip is a straight line (a Clip Line), a plane (a Clip Plane), a quadric surface (cylinder, sphere, etc.), a constant x, y, or z plane, a box, or an i, j, or k plane that passes through selected model Parts.
- EnSight calculates the values of variables at the nodes of the Clip.

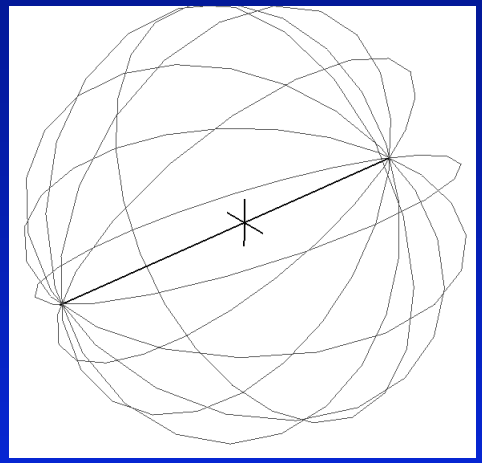


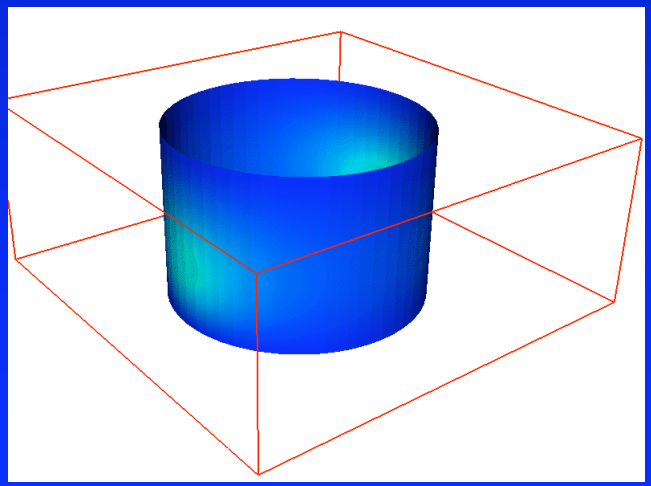


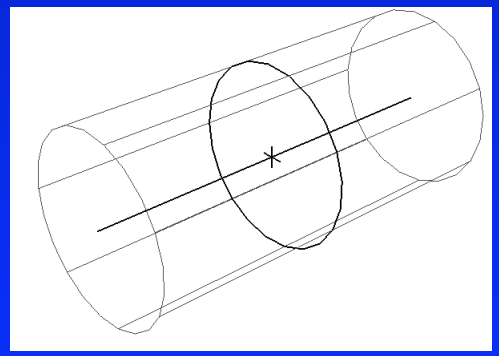
# Clips

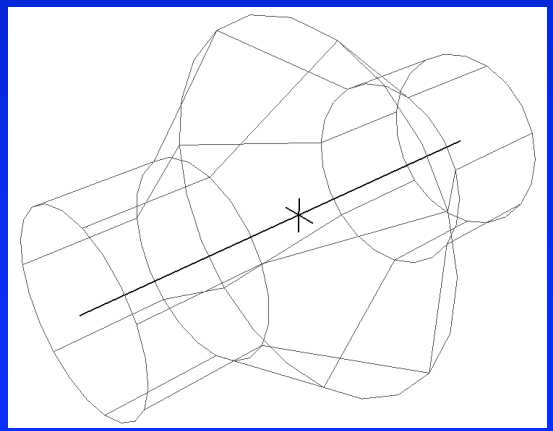










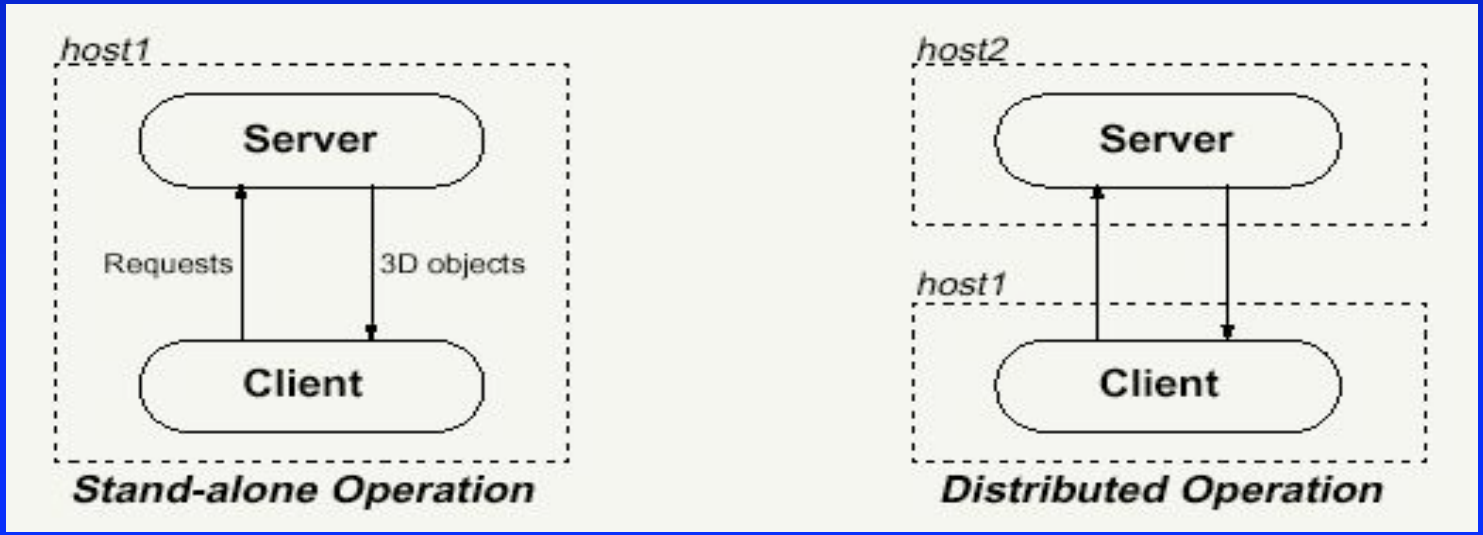


# Animation

- enables animation of particle traces
- provides animation of plane clips or isosurfaces (sweep through a model)
- allows "flipbook" animation of transient data
- allows model (mesh) movement, with or without changing topology
- provides keyframe animation for automated model fly-arounds and zooms
- supports animation recording

# EnSight's Client-Server Concept

- EnSight's distributed architecture takes advantage of networked resources by distributing the post-processing workload between server and client processes
- Two modes: stand-alone and distributed (we use distributed)



# EnSight's Client-Server Concept

- The server is generally installed on the more powerful machine and performs I/O and CPU intensive tasks
- Model geometries extracted from input data or computed by the server are sent to the client
- The client is generally installed on the machine with better graphics performance and renders the geometry to screen
- Multiple servers (up to 8) can be connected to a single client; this provides scalability by allowing each server to compute on a different portion of the data

# EnSight at TAMU

- Currently using version 7.3
- EnSight's client and server are both available on:
  - the 32 CPU SGI Origin 2000 (titan)
- The users of the Texas A&M Supercomputing Facility may download the client binaries for the Ensight client from the following website:
  - http://sc.tamu.edu/help/ensight73/Downloads
- Binaries for linux, SGI, and Sun are currently available at the site and those for HP, DEC, IBM, and windows NT/2000 workstations can be made available upon request.

# EnSight at TAMU

- To use EnSight, add the following to your .cshrc file on the server as well as the client:

```
setenv ENSIGHT7_HOME /usr/local/ensight73
setenv ENSIGHT7_ARCH sgi_6.5_n64
setenv ENSIGHT7_INPUT dummy
set path=($path $ENSIGHT7_HOME/bin)
```

- Note that the values of ENSIGHT7_HOME and ENSIGHT7_ARCH may be different for your client workstation (depending on how you installed EnSight).

# EnSight at TAMU

- For assistance on any aspect of EnSight use, please send email to: help@sc.tamu.edu
- The local support person for EnSight (Faisal Chaudhry) can be reached at 862-3107
- Complete EnSight documentation is available in hypertext form as online help. It is also available as a set of PDF files for printing hardcopy from:
  - http://sc.tamu.edu/help/ensight73/Manuals

# Starting EnSight

- Here's how you can invoke EnSight in unix:

  Open 2 windows on your workstation desktop. In one of them, log in to the Ensight server (titan), then type the following at the prompt (unless it is already in the .cshrc file):

```
setenv ENSIGHT7_HOME /usr/local/ensight73
setenv ENSIGHT7_ARCH sgi_6.5_n64
setenv ENSIGHT7_INPUT dummy
set path=($path $ENSIGHT7_HOME/bin)
```

  Repeat the same in the window for the local workstation.

  In the window with the local prompt, type: **ensight7.client -cm**
  In the window of the remote machine, type:

  **ensight7.server -c *local_workstation_name*.tamu.edu**

# Recovering from a crash

- If EnSight crashes while you are working, here is how you can recover from it and start from where you left off:
  - Every session of EnSight is recorded in what is known as an ensight backup command file.
  - When EnSight starts, you will see a message similar to the one below on the command line:
    - Backup file for this run of EnSight is /var/tmp/ensigCAAa003e_
  - The file **/var/tmp/ensigCAAa003e_** is the backup command file.
  - When EnSight crashes, rename this file and copy it to your current working directory. Edit this file to remove the last few lines (that probably caused the crash).
  - Now, start EnSight again as follows: **ensight7 –p *command_file_name***

# Recovering from a crash

```
VERSION 7.10
command: delay_refresh ON
data: native_binary ON
data: format case
data: path /usr/local/ensight71/data/ami
data: geometry ami.case
data: read
data_partbuild: begin
part: select_default
part: modify_begin
part: elt_representation not_loaded
part: modify_end
data_partbuild: data_type unstructured
        .
        .
        .
view_transf: function global
view_transf: translate -17.368887 -6.220861 0.000000
view_transf: function revolution
part: select_begin
 3
part: select_end
command: delay_refresh OFF
devsrf: begin
devsrf: origin 0.0000e+00 0.0000e+00 0.0000e+00
devsrf: axis 0.0000e+00 0.0000e+00 1.0000e+00
devsrf: seam_vector 7.7715e-01 6.2932e-01 0.0000e+00
devsrf: end
```

Insert on 2nd line

Insert on last line

Delete the commands associated with the last operation performed by EnSight

# Getting your data into EnSight

- EnSight supports a number of common data formats as well as interfaces to various simulation packages. There are four different means to get your data into EnSight
- Type 1 -- Direct (built-in) Readers
  - Are accessed by choosing the desired format in the Data Reader dialog. These include common data formats as well as a number of readers for commercial software.
- Type 2 -- User-Defined Readers
  - A library of routines is provided with EnSight to allow users to create their own custom interfaces. A number of User-Defined Readers are provided with EnSight; complete documentation and dummy routines may be found in the directory $ENSIGHT7_HOME/user_defined_src/readers.

# Getting your data into EnSight

- Type 3 -- Stand-Alone Translators
  - May be written by the user to convert data into EnSight format files. Several translators are provided with EnSight. These are found in the directory $ENSIGHT7_HOME/translators.
- Type 4 -- EnSight Format
  - The software supplier supports the EnSight format directly, i.e. an option is provided in their products to output data in EnSight5 or EnSight Case format.

# EnSight Data Interfaces

Types 1 & 4

- ABAQUS
- ANSYS
- CASE (Ensight6)
- CFX5
- Ensight 5
- ESTET
- FAST Unstructured
- FIDAP
- FIRE
- Fluent
- MOVIE.BYU
- MPGS 4.1
- N3S
- PLOT3D
- Polyflow
- SPHINX
- STAR-CD

Type 2

- CFF
- CFX4
- COBALT
- EXODUS II
- Flow-3D
- I-DEAS
- LS-DYNA
- MSC/Dytran
- MSC/Nastran
- PXI
- SCRYU
- STL
- TECPLOT
- VECTIS

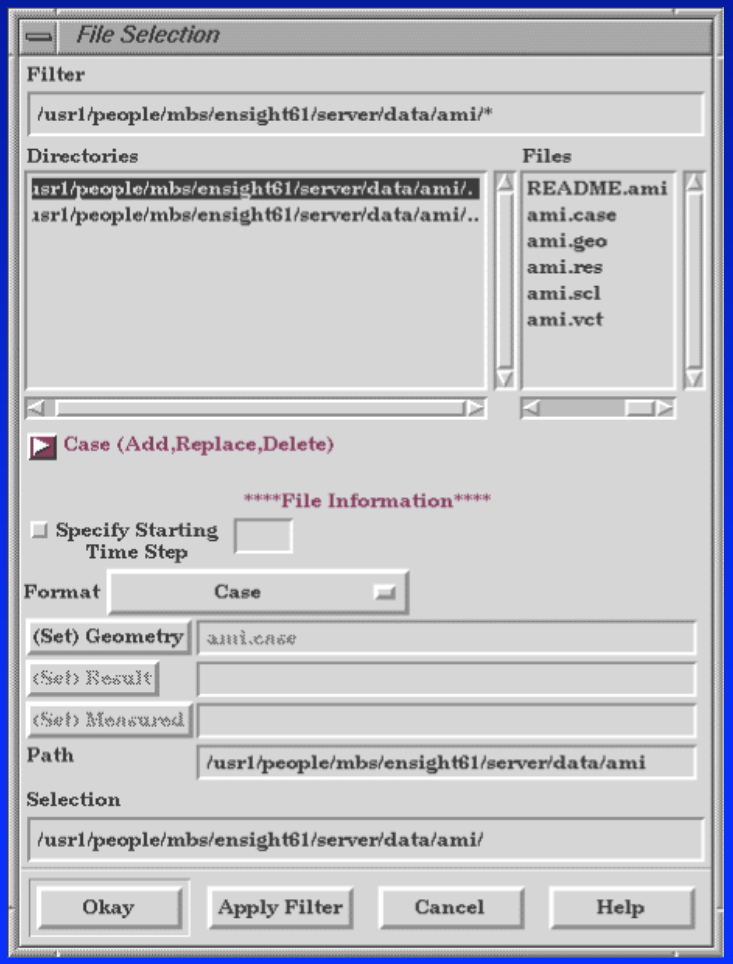
# Getting your data into EnSight

- EnSight typically operates on the following types of files:
  - **geometry** (required) -- defines the geometry of parts (nodes and connectivity)
  - **case** or **result** -- gives variable names and associated file names and time step information
  - **variable** -- one file for each variable, which contains data for each node defined in the geometry file
  - **measure/particle** -- contains experimental data on discrete particles for comparison to computed data
- EnSight files can be ASCII or binary
- For more information on EnSight files, see Chapter 2 of the EnSight User Manual

# Getting your data into EnSight

- Filter
- Directories
- Files
- Starting time step
- Format
- File input fields
  - Geometry
  - Results

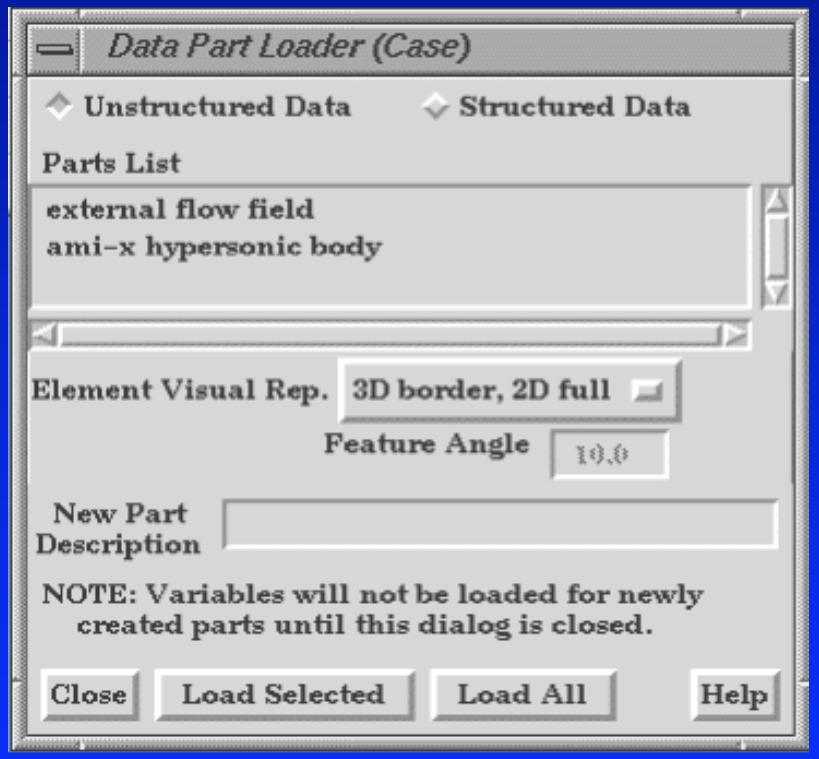
The Data Reader



# Getting your data into EnSight

- Data Representation
  - Unstructured Data
  - Structured Data
- Visual Representation
  - 3D border, 2D full
  - Border
  - Feature Angle
  - Full
  - Non-visual

The Data Part Loader

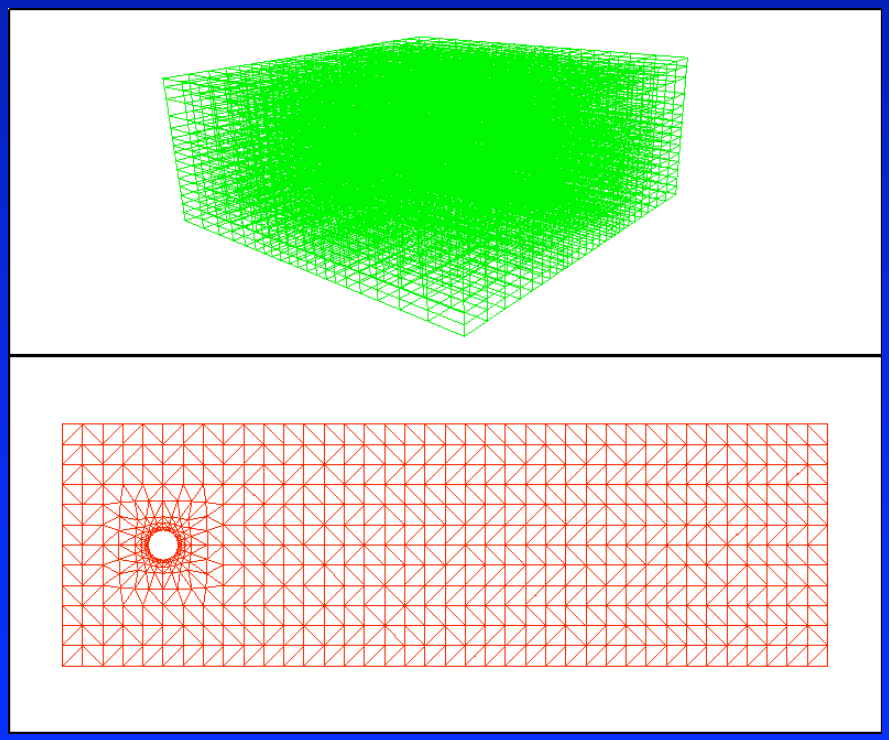


# Visual Representations

- Parts may be represented in one of a number of ways
  - Full
  - Border
  - 3D Border, 2D Full
  - Feature Angle
  - Bounding Box
  - Non-Visual
- The representation mode does **NOT** modify a part's geometry, it only affects what is rendered to the screen

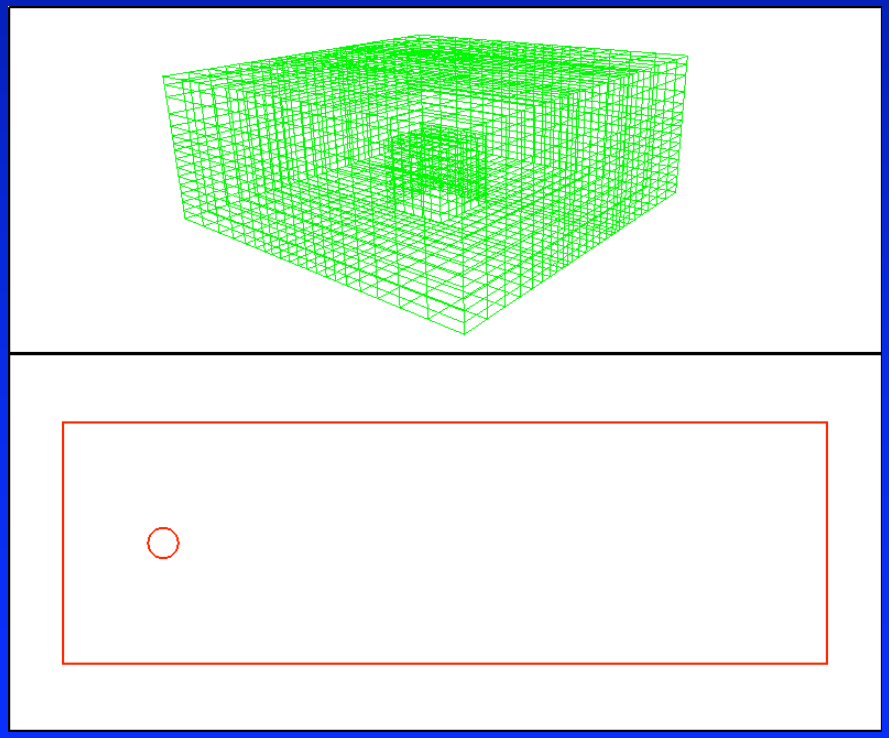
# Visual Representations

- Full
  - Every edge (2D elements) and every face (3D elements) is visible



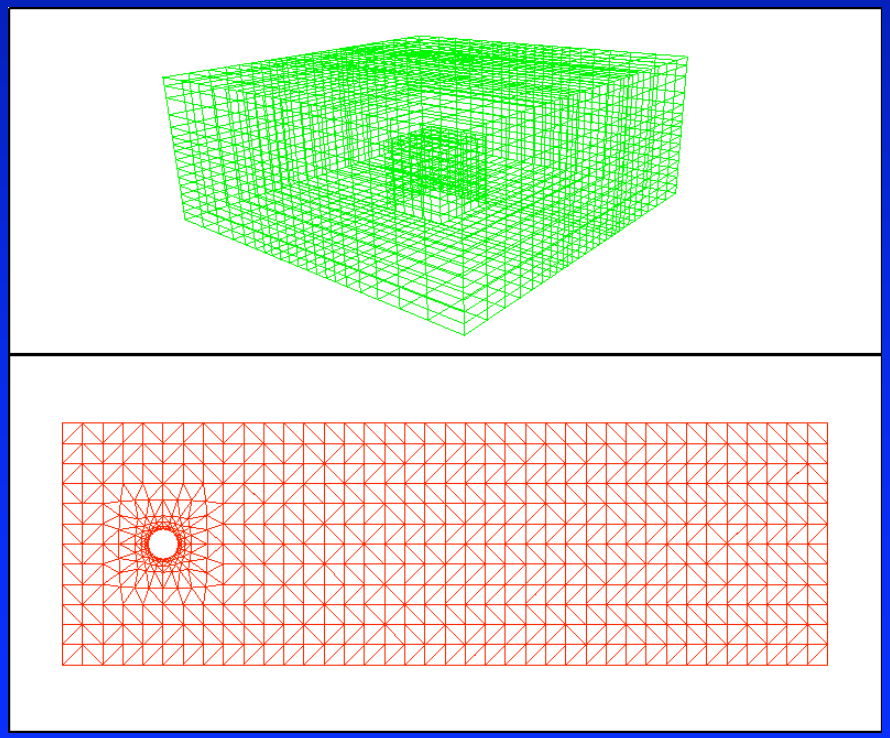
# Visual Representations

- Border
  - Shared edges (2D elements) and shared faces (3D elements) are removed



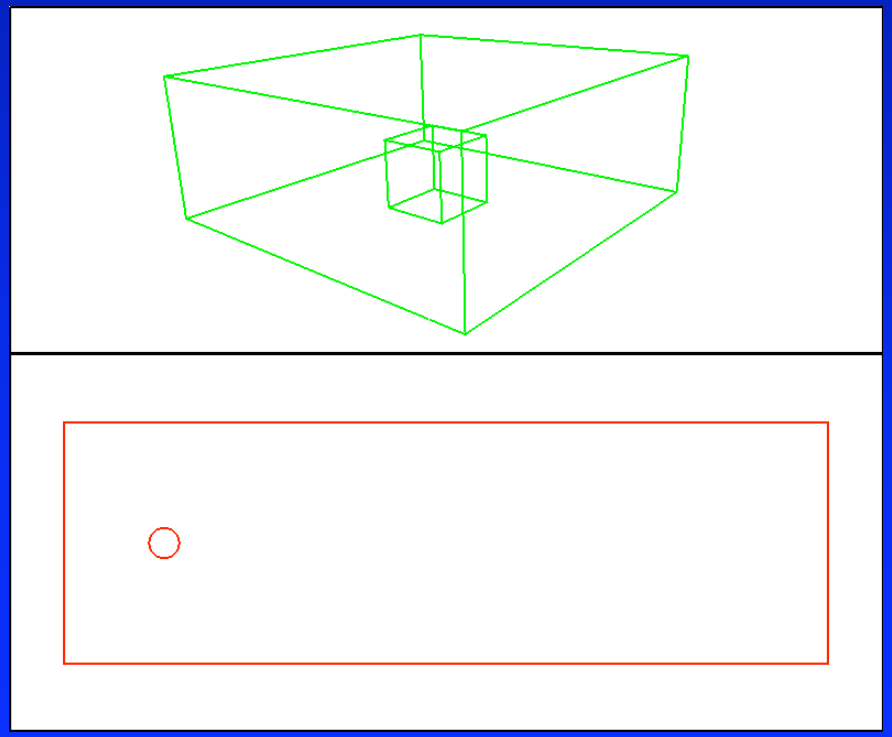
# Visual Representations

- 3D Border, 2D Full (Default)
  - 2D elements are displayed in full rep. mode, while 3D elements are displayed in border mode.



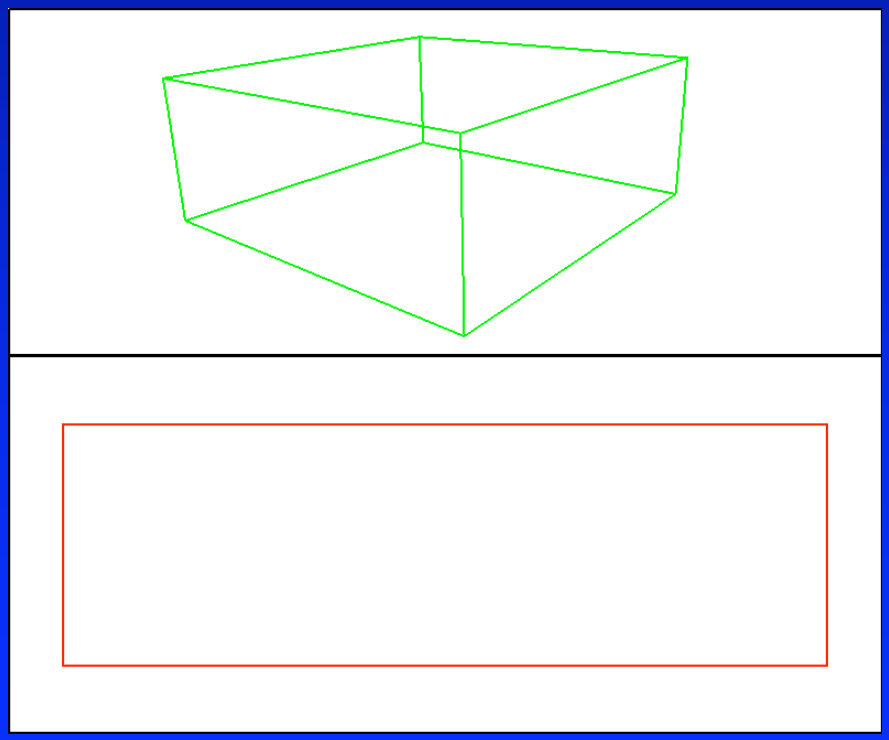
# Visual Representations

- Feature Angle
  - Looks at 2D element normals. The edges between 2D elements are removed if the angle is less than what the user specified.
  - For 3D elements, operates off of Border elements



# Visual Representations

- Bounding Box
  - Displays a bounding box around geometry

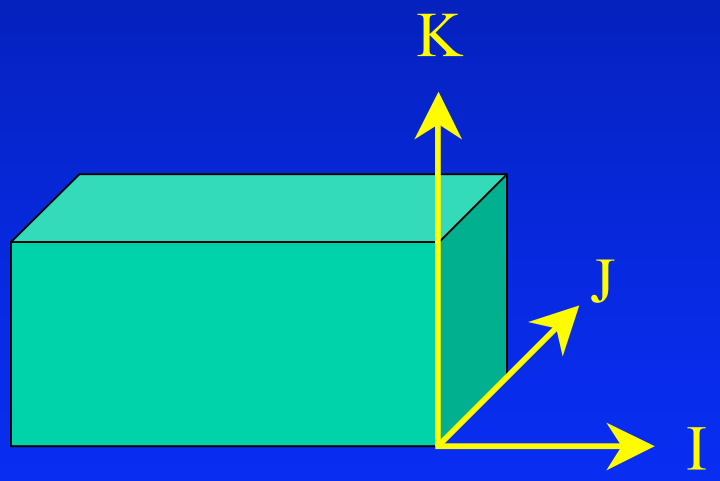


# Visual Representations

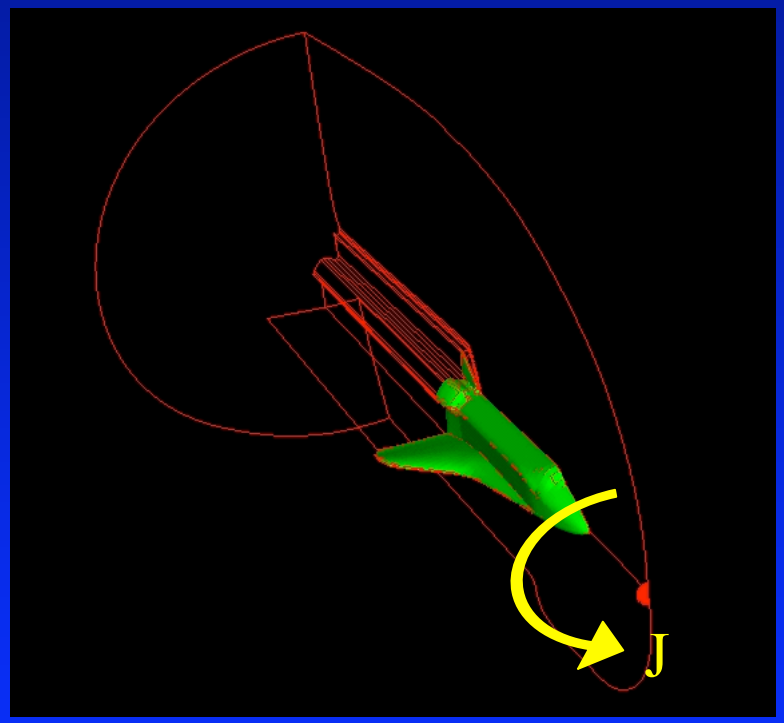
- Non-Visual
  - The part is kept only on the EnSight server.  It's geometry is not displayed on the EnSight client.
  - Useful for external flow-fields

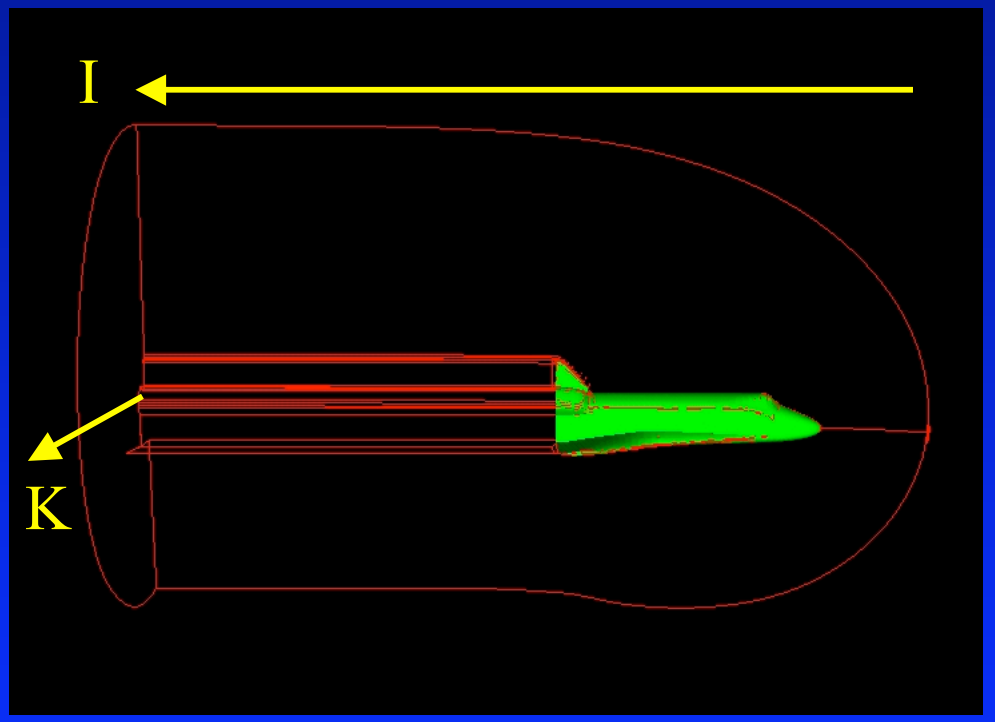
# Structured vs. Unstructured Grids

- EnSight supports both unstructured and block structured grids.
- A block structured grid is a curvilinear grid.
- Think of such a grid as a brick, whose length, width, and height are called I, J, and K and where each (I,J,K) point has an associated physical space coordinate (x,y,z).
- All structured grids are topologically equivalent to such a brick.

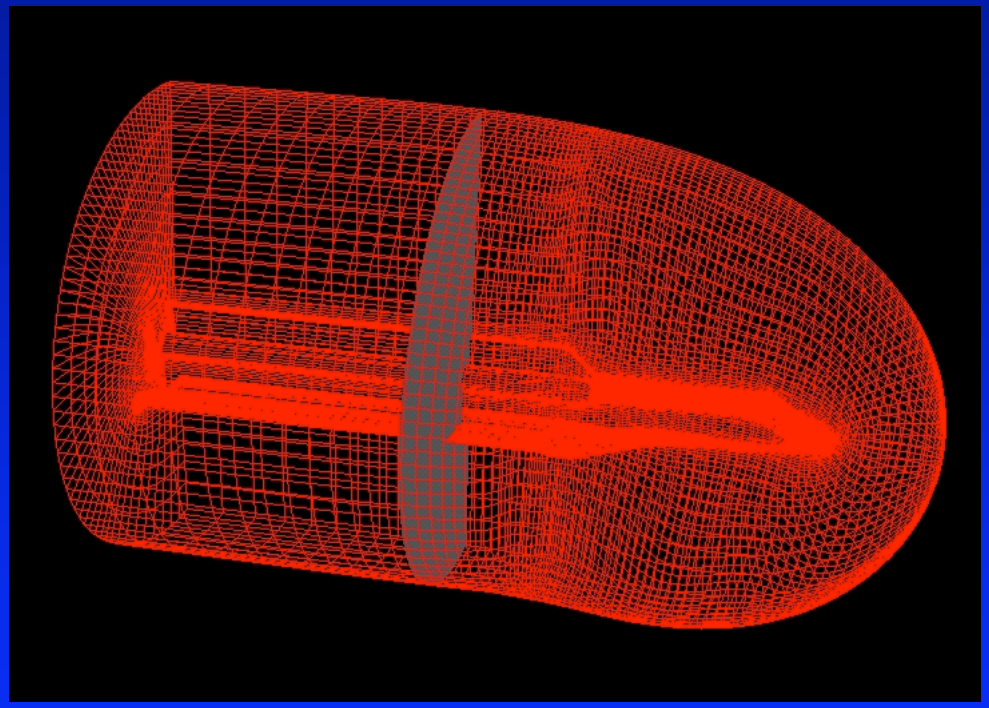


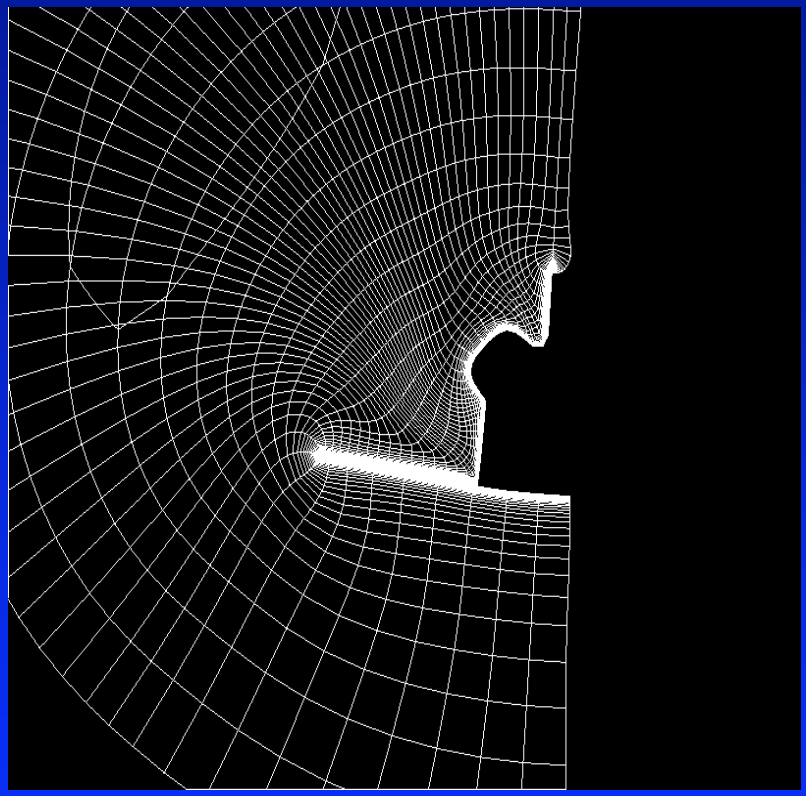
# Structured grid example



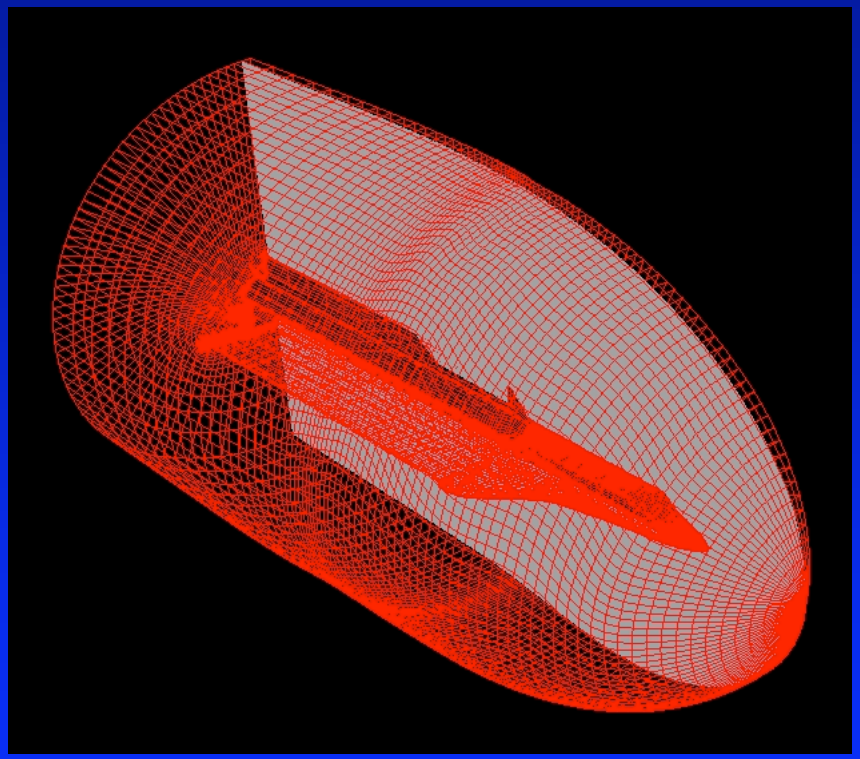



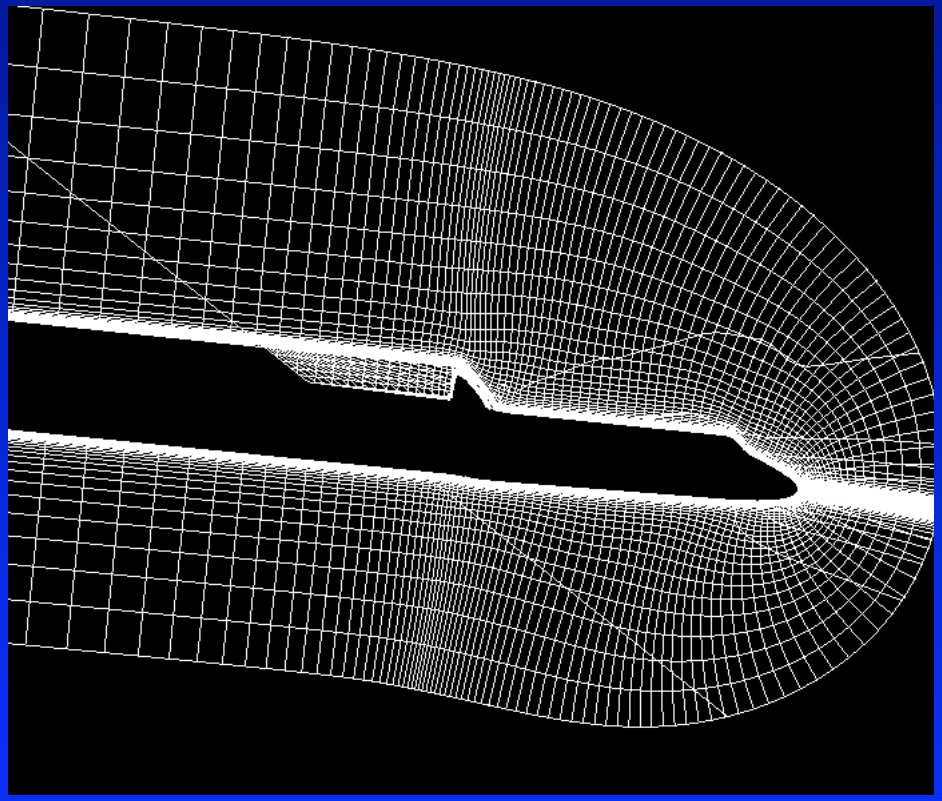
# Structured grid example





# Structured grid example

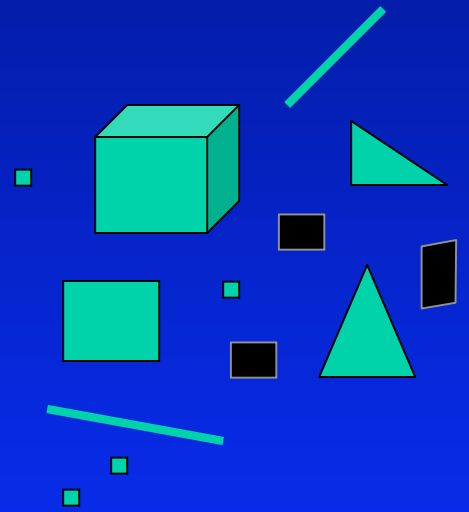




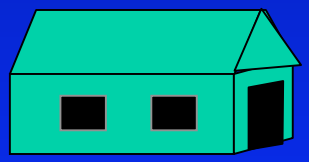
# The Building Blocks

…for unstructured grids.

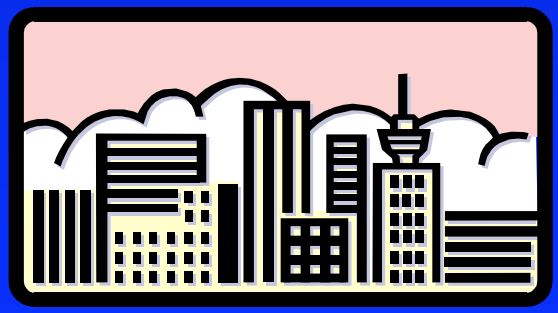
Element



Part

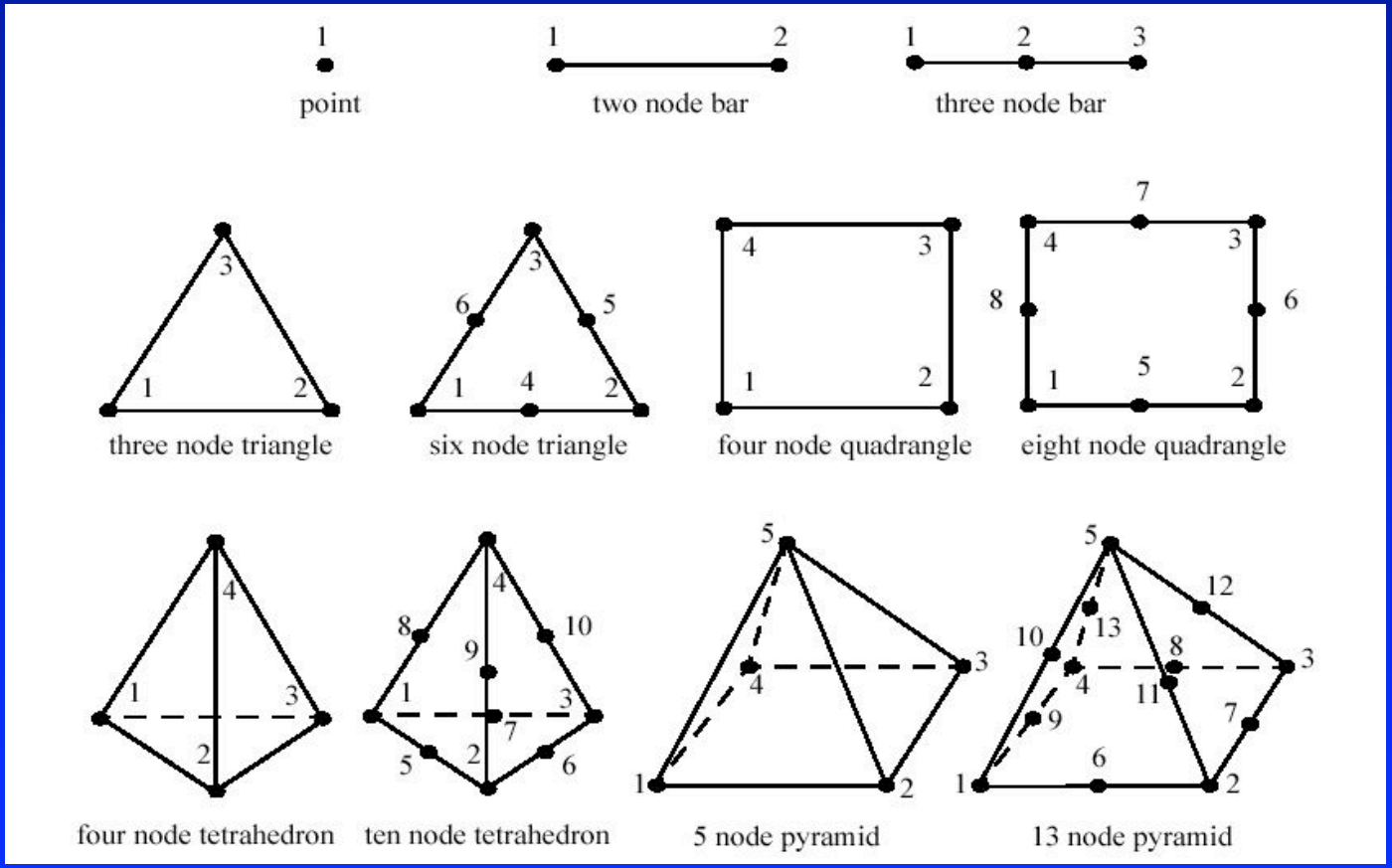


Case



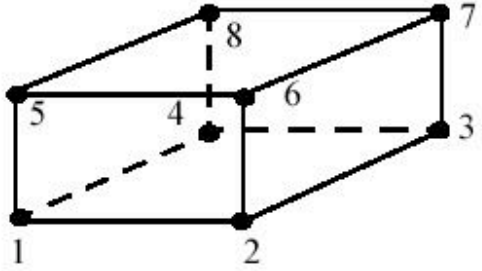
# Supported Element Types

…for unstructured grids.

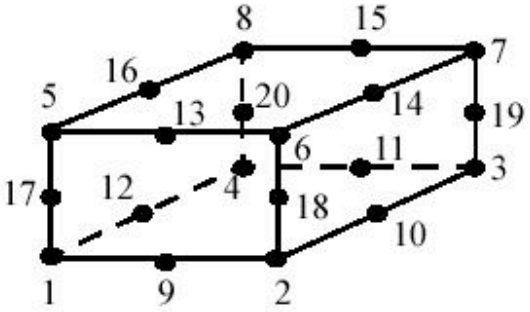


# Supported Element Types

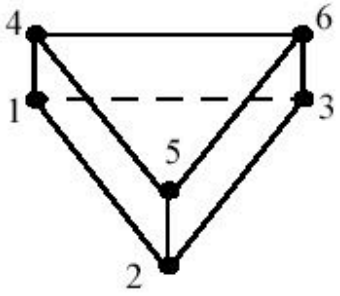
…for unstructured grids.



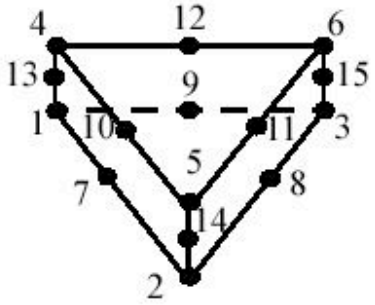

eight node hexahedron




twenty node hexahedron




six node pentahedron (wedge)

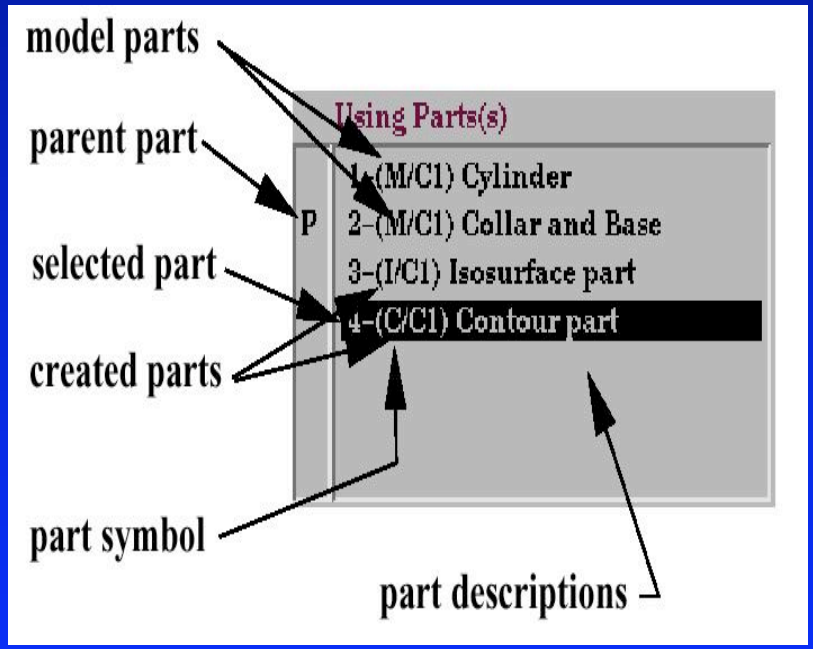



fifteen node pentahedron (wedge)

# Parts

- A collection of nodes and elements that share the same attributes.
- There are two kinds of parts
  - model parts, which are read in from data files
  - created parts, such as isosurfaces
- Parts can also be thought of as
  - parent parts
  - child parts
- Anytime a parent part changes, its dependent parts will automatically be updated.

The Main Parts List shows all parts:



# Cases

- A “case” is another name for a dataset (collection of data files).
- EnSight allows up to eight cases to be loaded simultaneously.
- Among other things, cases can be used to compare similar data sets created from different codes.
- Each new case starts a new server process which connects to your EnSight client. Thus, cases can be on different machines. You may have to start a server manually for each new case.

# Frames

- Frames are 3D coordinate systems within which objects are defined. A part is always positioned in the virtual 3D world in reference to its frame.
- All parts are initially assigned to frame 0. You can create new frames and assign one or more parts to them. Then you can apply transformations either globally or to individual frames.
- Frames are useful for transforming (translating, rotating, scaling) parts independently of each other.
- Symmetry operations (reflections about axes) are done with respect to a frame's origin.
- Note: A part can be assigned to only one frame at a time.

# A Tour of the EnSight GUI

- We will review…
- Where the different user interface components are located and what they do.
- The six modes of the user interface.
- Some User interface conventions

**Message Area**

**Information Area Button**

Click to see information dialog.

**Quick Interaction Area**

Interface controls associated with the current feature selected from the Feature Icon Bar.

**Main Menu**

**Feature Icon Bar**

Sets the current feature. Click an icon to open the associated Quick Interaction area.

**Main Parts List**

All parts from your model as well as created parts (*e.g.* clips, isosurfaces) are listed here. Click an item to select part(s) to operate on.

**Mode Selection Area**

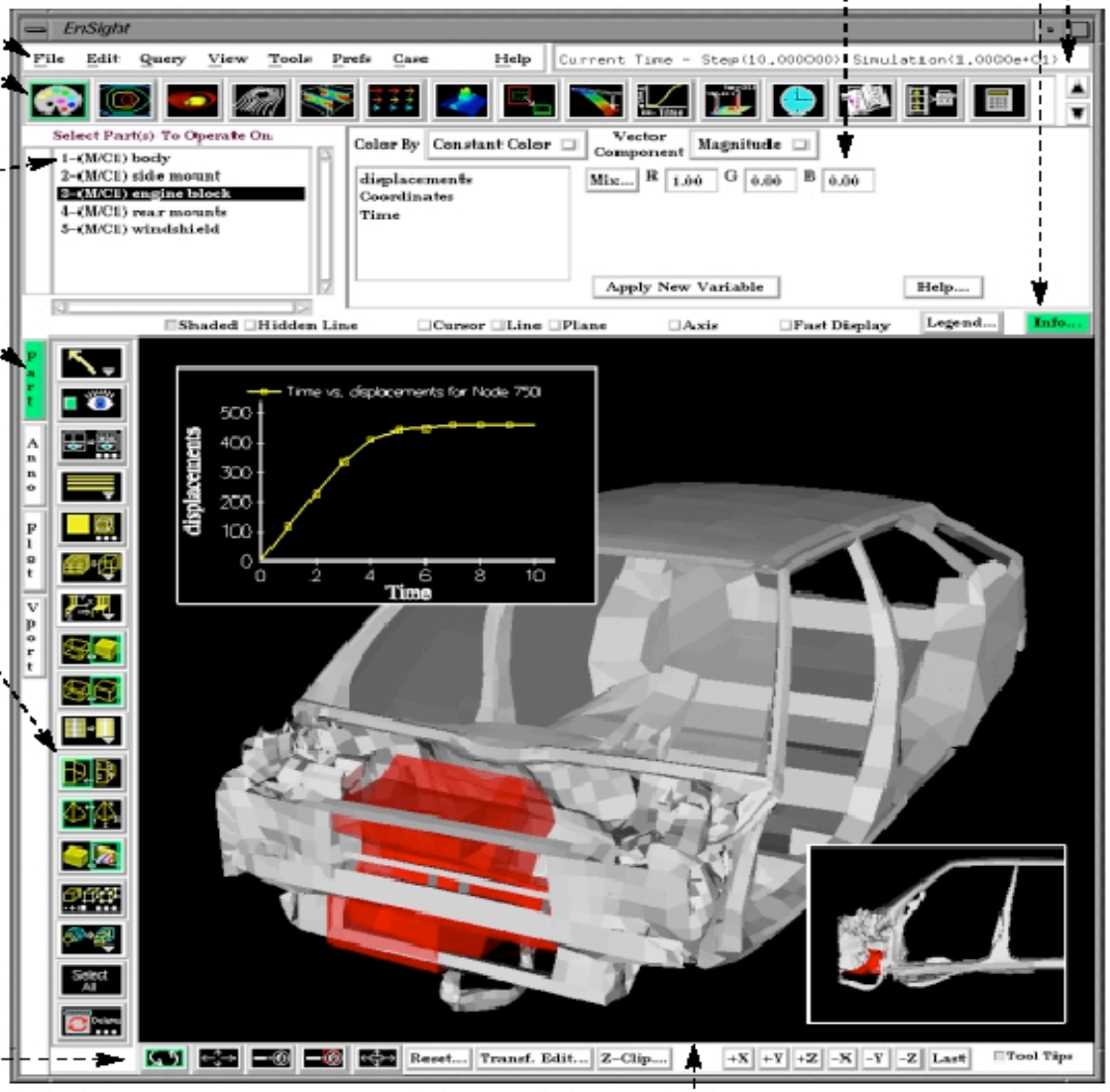
Sets the major mode of EnSight (Part, Annot, Plot, VPort, ...) and loads the applicable set of icons into the vertical Mode Icon Bar. Click the button to select the Mode.

**Mode Icon Bar**

The set of icons associated with the current Mode. Click the icon to access the function. Click and hold the left mouse button to display a short description of the icon in the Message Area. Use the vertical scroll bar to access the remainder of the icons.

**Transformation Control Area**

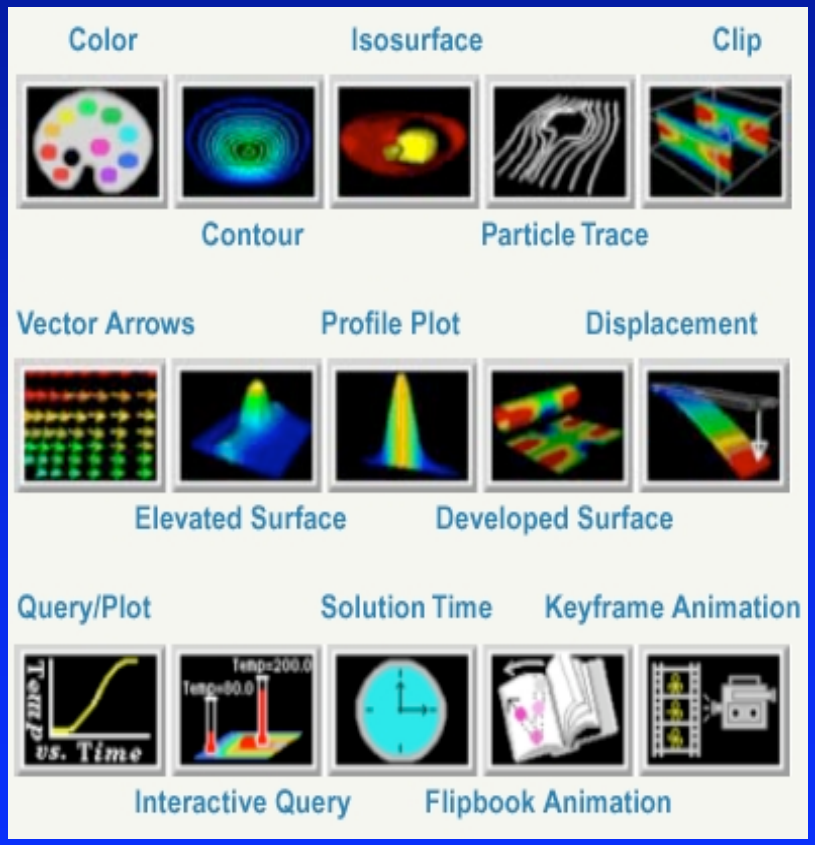
Buttons that control the current transformation operation (*e.g.* rotate or translate) associated with mouse action in the Graphics Window. Other buttons open dialogs providing detailed transformation control.




**Graphics Window** showing inset plot and viewport

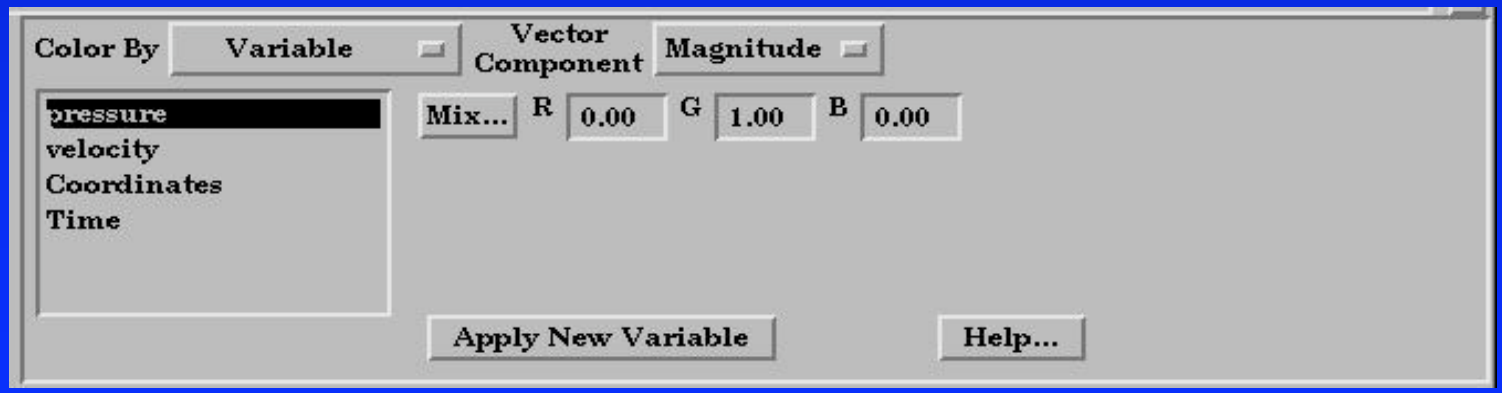
# Feature Icon Bar

- Contains icons to access all the major visualization features of EnSight.
- Clicking the left mouse button on an icon selects the feature and opens its basic controls in the Quick Interaction Area.
- Double clicking on an icon brings up a separate Feature Detail Editor dialog which contains more complete controls for the selected feature.



# Quick Interaction Area

- Provides basic interface controls for the feature currently selected in the Feature Icon Bar. Changes in this area typically affect the parts currently selected in the Main Parts List
- Contents of the Quick Interaction Area change with the currently selected feature
- Shown below is the Quick Interaction Area for the Color Parts feature which provides controls for setting the color of the parts currently selected in the Main Parts List.



# Mode Selection Area & Mode Icon Bar

- Mode Selection Area contains 6 buttons for selecting one of the 6 modes of the user interface.
- Mode Icon Bar displays a list of icons associated with the currently selected mode of the interface.
- Shown is the Mode Icon Bar for Part Mode containing icons which control the visibility and display characteristics of individual parts.

# Transformation Control Area

- Provides icons which control various aspects of object transformations including rotation, translation, zoom, rubber band zoom and scaling.
- Reset ... opens the Reset Tools and Viewports dialog.
- Transf Edit ... opens the Transformation Editor.
- Z Clip ... opens the Transformation Editor's Z Clip mode.

# User Interface Modes

- There are 6 user interface modes. The current mode is selected by clicking on the desired button in Mode Selection Area.
- View Mode controls various global viewing attributes. Many of the View Mode icons have counterparts in Part Mode. The View Mode icon acts as a global toggle while the Part Mode icon applies only to the parts currently selected in the Main Parts List.
- Part Mode icons control various attributes such as visibility of the parts currently selected in the Main Parts List.
- Annotation Mode provides control over various annotation entities such as text and color legends.

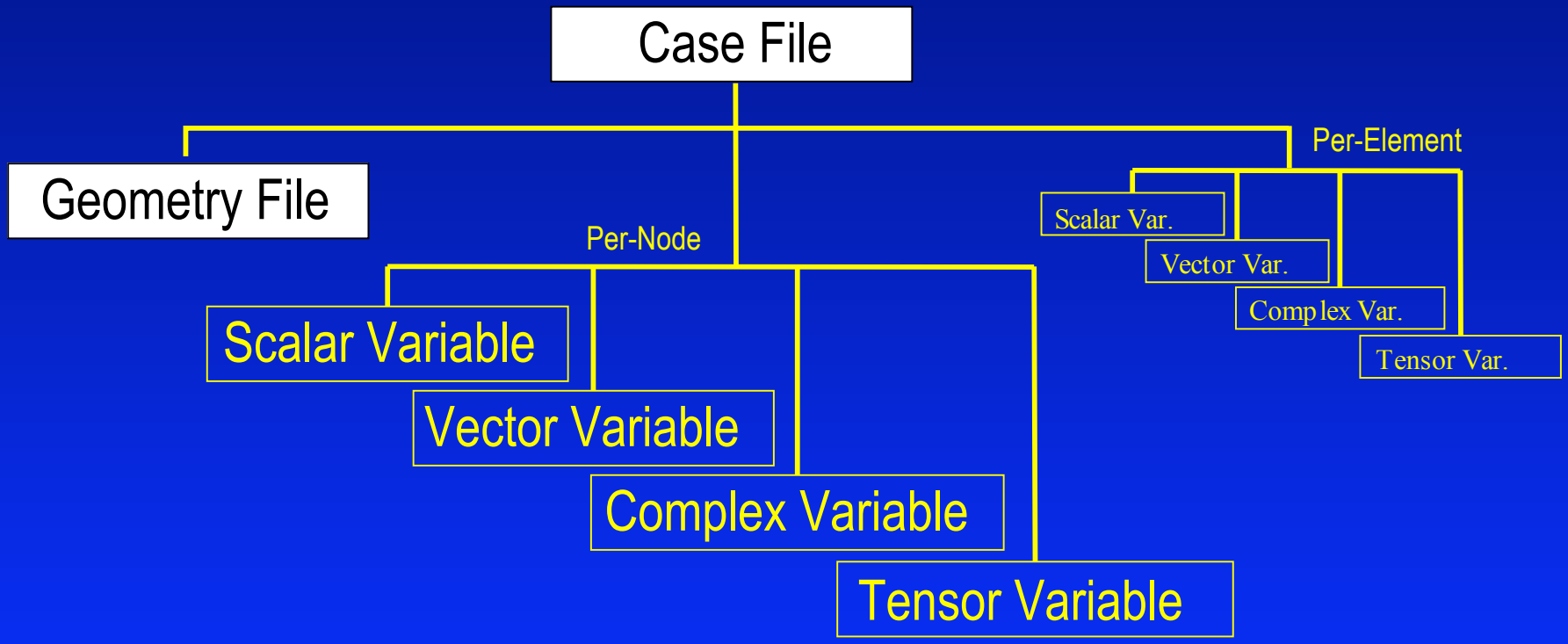
# User Interface Modes

- Plot Mode provides control over the appearance and behavior of X Y plotters in the Graphics Window.
- Viewport Mode provides control over the size and appearance of multiple viewports in the Graphics Window.
- Frame Mode provides control over multiple frames of reference which can be positioned independently of one another.

# Some User Interface Conventions

- Editable Text Fields
  - Place the mouse cursor in the field and click to insert a blinking insertion cursor. Double click to select a single word. Triple click to select a whole string.
- IMPORTANT NOTE
  - Generally, you must type return while the blinking cursor is still in the field for the changes to take effect!
  - However, one exception to this rule is the text fields for typing in file names in the File Selection dialog.

# Sample Dataset



# Sample Data (EnSight Case Format)

en6.case

```
FORMAT

type:   ensight

GEOMETRY

model:  en6.geo

VARIABLE

constant per case:          Cden  .8

scalar per element:         Esca  en6.Esca
scalar per node:           Nsca  en6.Nsca

vector per element:         Evec  en6.Evec
vector per node:           Nvec  en6.Nvec

tensor symm per element:     Eten  en6.Eten
tensor symm per node:       Nten  en6.Nten

complex scalar per element:  Ecmp  en6.Ecmp_r  en6.Ecmp_i  2.
complex scalar per node:     Ncmp  en6.Ncmp_r  en6.Ncmp_i  4.
```

# en6.geo

```
This is the 1st description line of the EnSight6 geometry example
This is the 2nd description line of the EnSight6 geometry example
node id given
element id given
coordinates
    11
    15 4.00000e+00 0.00000e+00 0.00000e+00
    31 3.00000e+00 0.00000e+00 0.00000e+00
    20 5.00000e+00 0.00000e+00 0.00000e+00
    40 6.00000e+00 0.00000e+00 0.00000e+00
    22 5.00000e+00 1.00000e+00 0.00000e+00
    44 6.00000e+00 1.00000e+00 0.00000e+00
    55 6.00000e+00 3.00000e+00 0.00000e+00
    60 5.00000e+00 0.00000e+00 2.00000e+00
    61 6.00000e+00 0.00000e+00 2.00000e+00
    62 6.00000e+00 1.00000e+00 2.00000e+00
    63 5.00000e+00 1.00000e+00 2.00000e+00
```

# en6.geo (cont'd)

```
part 1
2D uns-elements (description line for part 1)
tria3
      2
    102     15     20     22
    103     22     44     55
hexa8
      1
    104     20     40     44     22     60     61     62     63
part 2
1D uns-elements (description line for part 2)
bar2
      1
    101     31     15
part 3
3D struct-part (description line for part 3)
block iblanked
      2      3      2
 0.00000e+00 2.00000e+00 0.00000e+00 2.00000e+00 0.00000e+00 2.00000e+00
 0.00000e+00 2.00000e+00 0.00000e+00 2.00000e+00 0.00000e+00 2.00000e+00
 0.00000e+00 0.00000e+00 1.00000e+00 1.00000e+00 3.00000e+00 3.00000e+00
 0.00000e+00 0.00000e+00 1.00000e+00 1.00000e+00 3.00000e+00 3.00000e+00
 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00 0.00000e+00
 2.00000e+00 2.00000e+00 2.00000e+00 2.00000e+00 2.00000e+00 2.00000e+00
      1      1      1      1      1      1      1      1      1      1
      1      1
```

# en6.Esca

```
Per_elem scalar values for the EnSight6 geometry example
part 1
tria3
 2.00000e+00 3.00000e+00
hexa8
 4.00000e+00
part 2
bar2
 1.00000e+00
part 3
block
 5.00000e+00 6.00000e+00
```

# en6.Evec

```
Per_elem vector values for the EnSight6 geometry example
part 1
tria3
 2.10000e+00 2.20000e+00 2.30000e+00 3.10000e+00 3.20000e+00 3.30000e+00
hexa8
 4.10000e+00 4.20000e+00 4.30000e+00
part 2
bar2
 1.10000e+00 1.20000e+00 1.30000e+00
part 3
block
 5.10000e+00 6.10000e+00
 5.20000e+00 6.20000e+00
 5.30000e+00 6.30000e+00
```

# en6.Nvec

Per_node vector values for the EnSight6 geometry example
 1.10000e+00 1.20000e+00 1.30000e+00 2.10000e+00 2.20000e+00 2.30000e+00
 3.10000e+00 3.20000e+00 3.30000e+00 4.10000e+00 4.20000e+00 4.30000e+00
 5.10000e+00 5.20000e+00 5.30000e+00 6.10000e+00 6.20000e+00 6.30000e+00
 7.10000e+00 7.20000e+00 7.30000e+00 8.10000e+00 8.20000e+00 8.30000e+00
 9.10000e+00 9.20000e+00 9.30000e+00 1.01000e+01 1.02000e+01 1.03000e+01
 1.11000e+01 1.12000e+01 1.13000e+01
part 3
block
 1.10000e+00 2.10000e+00 3.10000e+00 4.10000e+00 5.10000e+00 6.10000e+00
 7.10000e+00 8.10000e+00 9.10000e+00 1.01000e+01 1.11000e+01 1.21000e+01
 1.20000e+00 2.20000e+00 3.20000e+00 4.20000e+00 5.20000e+00 6.20000e+00
 7.20000e+00 8.20000e+00 9.20000e+00 1.02000e+01 1.12000e+01 1.22000e+01
 1.30000e+00 2.30000e+00 3.30000e+00 4.30000e+00 5.30000e+00 6.30000e+00
 7.30000e+00 8.30000e+00 9.30000e+00 1.03000e+01 1.13000e+01 1.23000e+01

# en6.Eten

```
Per_elem symmetric tensor values for the EnSight6 geometry example
part 1
tria3
 2.10000e+00 2.20000e+00 2.30000e+00 2.40000e+00 2.50000e+00 2.60000e+00
 3.10000e+00 3.20000e+00 3.30000e+00 3.40000e+00 3.50000e+00 3.60000e+00
hexa8
 4.10000e+00 4.20000e+00 4.30000e+00 4.40000e+00 4.50000e+00 4.60000e+00
part 2
bar2
 1.10000e+00 1.20000e+00 1.30000e+00 1.40000e+00 1.50000e+00 1.60000e+00
part 3
block
 5.10000e+00 6.10000e+00
 5.20000e+00 6.20000e+00
 5.30000e+00 6.30000e+00
 5.40000e+00 6.40000e+00
 5.50000e+00 6.50000e+00
 5.60000e+00 6.60000e+00
```

en6.Ecmp_i

```
Per_elem complex imaginary scalar values for the EnSight6 geometry example
part 1
tria3
 2.20000e+00 3.20000e+00
hexa8
 4.20000e+00
part 2
bar2
 1.20000e+00
part 3
block
 5.20000e+00 6.20000e+00
```

en6.Ecmp_r

```
Per_elem complex real scalar values for the EnSight6 geometry example
part 1
tria3
 2.10000e+00 3.10000e+00
hexa8
 4.10000e+00
part 2
bar2
 1.10000e+00
part 3
block
 5.10000e+00 6.10000e+00
```

# Other Features

# Command Language

- allows batch processing provides a counterpart for every user action in the GUI
- automatically records commands into file for editing and playback
- allows commands to be saved as named macros
- allows macros to be replayed at any time or to be bound to keyboard keys
- allows sessions to be archived in binary form and then quickly restored

# Geometry

- handles structured, unstructured, hybrid and overlapping meshes
- allows native structured data to be viewed along constant I/J/K planes
- allows geometry to be varied with time, with or without changes to mesh topology
- offers 1D, 2D and 3D elements in linear or quadric form

# Parts

- provides individual manipulation and attribute control of analysis mesh or derived (clip planes, isosurfaces, particle traces, etc.) parts
- allows parts to be copied, cut, merged into a single part, and converted to a new representation
- enables part copy to be positioned independent of the original part in order to display a different variable

# Attributes

- Provides control of the following attributes on a global or per-part basis:
  - visibility of elements, lines or nodes
  - transparency (simple screen door or alpha shading)
  - color
  - line, hidden line and surface display
  - line style and thickness
  - lighting parameters
  - representation mode (3D, edge, feature angle)
  - element shrink factor
  - symmetry operations

# Results Data & Variables

- enables users to load and visualize multiple scalar and vector variables simultaneously
- conserves memory by allowing variables to be selectively loaded and unloaded
- provides node-based, cell-center-based, or mixed operations
- allows variables from different time steps to be displayed simultaneously

# Results Data & Variables

- provides full support for all types of transient and periodic data, including rotational, translational and mirror
- offers built-in calculator for calculating new variables from existing ones
- allows point data (from experiments, multi-phase flow or particle/impact simulations) with attached scalar and vector variables to be loaded and displayed with or without mesh-based results; both position and variables may be transient

# Transient Analysis

- allows time steps to be changed at the click of a button; automatically recalculates and redisplays existing objects to reflect each new state
- provides interpolation between time steps for low-resolution datasets
- provides dynamic plots that are linked to the transient display of parent part variables

# Quantitative Analysis / Data Query / Plotting

- enables arbitrary points, nodes, elements and parts to be queried for information
- provides interactive probe/query capability that allows variables to be displayed at a given mouse location or at the nearest node on any part
- allows queries to be performed along a line in space or on a part defined with 1D elements
- allows data queries of any variable over distance or time to be computed and saved as a table of data or used for plotting purposes

# Quantitative Analysis / Data Query / Plotting

- provides a full-function 2D plotter to display any variable over distance or time
- allows all plot attributes - such as color, background color, size, axis appearance and others - to be modified individually for each plot appearing in the graphics window
- allows external data such as measurements to be loaded and appear in a plot, with or without data from analyses

# Output

- offers stereo viewing for cost-effective, desktop VR
- supports immersive VR environments
- supports VRML, JPEG and MPEG output for distributing images and animations via the Internet and intranets outputs advanced "Move-Draw" PostScript, encapsulated PostScript and HP-GL files with compact, high-quality images that maintain screen resolution even when resized within other applications; also supports RGB, PICT and other output formats